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The Maryland Integrated Pest Management Gypsy Moth Project 1983-1987

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This report was a cooperative effort of the following individuals:

Richard Reardon, USDA Forest Service, Northeastern Area, State and Private Forestry, Morgantown, WV 26505

Lee Venables, USDA Agricultural Research Service, Beltsville, MD 20705

Andy Roberts, Virginia Polytechnic Institute and State University, Department of Entomology, Blacksburg, VA 24061

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Abstract

Federal, State, and County agencies, led by the USDA Forest Service conducted the Maryland Integrated Pest Management Gypsy Moth Project (MD-IPM Project) between 1983 and 1987. The MD-IPM Project was a pilot program designed to determine the feasibility of managing gypsy moth populations using an Integrated Pest Management (IPM) approach over a wide range of ecological, geographical, and land use areas. The project area covered 18 USGS 7.5-minute quadrangles in portions of Anne Arundel, Prince Georges and Howard Counties, Maryland. The project area was divided into a treatment area where IPM was implemented and a comparison area where the standard operational Cooperative Suppression Program was applied. Field personnel used USDA milk-carton pheromone traps located at 1-km grid points, and conducted egg mass surveys at 1-km grid points and within 1-km^2 cells. The data collection, management, and presentation techniques developed during the project represented a prototype effort for gypsy moth which relied on geographic information system computer technologies. Major emphasis was placed on evaluation and development of gypsy moth specific intervention tactics (e.g., Gypchek, inherited sterility, and mating disruption) for operational use. The MD-IPM Project initiated developing an improved formulation for Gypchek and demonstrated its efficacy in both ground and aerial applications. These evaluations led to the standard formulation and application parameters recommended for use since 1987, as well as provided the stimulus for several companies to attempt commercial production of Gypchek. The project sponsored the first pilot release of F1 sterile eggs to manage leading-edge populations of the gypsy moth. Also, during the project, efficacy data was collected to support the registration of the NRD-12 strain of Bt for control of gypsy moth. This project was a critical initial step in the continued development of an IPM approach for managing gypsy moth. It provided the basis for the Appalachian Integrated Pest Management Gypsy Moth Project.

Introduction

During the 1970's, State and Federal gypsy moth managers recognized the need to develop an integrated pest management (IPM) approach for gypsy moth Lymantria dispar (L.), in the eastern United States. Between 1975 and 1978, the U.S. Department of Agriculture (USDA) initiated a multidisciplinary research, development and application program to elucidate the natural processes operating against the gypsy moth and to further evaluate intervention activities for use against low-to-high density populations (Doane and McManus 1981). This effort provided sufficient data for the USDA to initiate a prototype IPM program against expanding low-density gypsy moth populations in addition to the on-going Cooperative Suppression Program which had been established in 1973 and directed against high-density populations (more than 621 egg masses (EM) per hectare or 250 EM per acre).

In 1981, a USDA Gypsy Moth Steering Committee sponsored the development of a cooperative gypsy moth IPM demonstration project. Committee members from the Animal and Plant Health Inspection Service (APHIS) and the Forest Service prepared a proposal. Along with representatives from the Agricultural Research Service (ARS), they identified broad objectives and a project area and allocated resources among participating agencies. These USDA agencies initiated the Maryland Integrated Pest Management Gypsy Moth Project (MD-IPM Project) as a 5-year (1983-1987) cooperative effort involving Federal, State, County and local agencies and organizations. This publication describes project components, activities to involve and inform the public, and technological accomplishments for the MD-IPM Project.

Technical Coordinating Committee

A Project Coordinator and Technical Coordinating Committee (hereafter, the committee) were appointed in 1982. Their task was to provide overall direction, to prepare a 5-year plan of work, and to more precisely identify a project area. The committee was composed of one technical representative from each cooperating agency (Reardon et al. 1987).

The committee selected the State of Maryland for the project area over other States for these reasons: male moth survey data for a standardized grid of traps was available; it encompassed a diversity of forest types; it had a gradient of gypsy moth infestations; and an organized gypsy moth program was present. Maryland's natural resources were readily accessible in graphic form through the Maryland Automated Geographic Information System (MAGI).

The project's goal was to use an IPM approach to determine the feasibility of managing gypsy moth populations at low- to moderate-levels over a wide range of ecological, geographic and land-use areas, and to delay populations from expanding further. The project emphasized using natural controls and integrating compatible prevention and control actions at an earlier stage of pest population development than was normally practiced in gypsy moth suppression programs.

The project had three objectives: (1) to maintain population levels below predefined thresholds in areas of management concern; (2) to evaluate and bring to operational use survey, monitoring and intervention technology developed during the USDA accelerated program (1975-78); and (3) to compare this IPM approach for managing low-density populations to the standard cooperative suppression approach for managing high-density gypsy moth populations.

The Maryland Department of Agriculture (MDA) hired three full-time entomologists (field, assistant field, and laboratory) to coordinate all activities planned by the committee. A crew of 15 to 25 employees was hired on a seasonal basis each year to support field and laboratory activities. The average annual budget for the project was $441,200 with approximately 76 percent of the annual budget allocated for salaries and an additional 9 percent for transportation costs to support field activities.

Project Area

The committee recommended that the project area should contain the following conditions: gypsy moth populations at levels below those causing visible defoliation but capable of increasing to outbreak levels within 4 years; forest types susceptible to gypsy moth; and forested areas representing various land-use categories and having different management objectives.

In 1983, project personnel established a survey and monitoring system on a 1-km grid which was geographically referenced using Universal Transverse Mercator (UTM) coordinates within an area in Maryland. This area included portions of five counties: Howard, Prince Georges, Anne Arundel, Calvert, and Charles. The objective of this system was to obtain intensive life stage data to more precisely define a project area. At a subset of accessible grid points, project personnel placed a standard milk carton pheromone trap and conducted egg mass surveys at the grid points and in the surrounding 1-km^2 cells (i.e., area bordered by four grid points). Also, in 1983, project personnel sent a letter to residents of approximately 55,000 single-family, detached homes within the five-county area. This letter alerted residents about the project and requested information concerning localized gypsy moth "hot spots", which was used to supplement the project's survey method using a limited number of egg mass surveys within the 1-km^2 cells.

Criteria for selecting the project area were a range of low- (<25) to moderate-density (25 to 250 EM/ha) populations available during the project, and a gradient of susceptible forest types within an area of manageable size. The committee used male moth and egg mass data collected in 1983 to select a project area that included land covered by 18 USGS 7.5- minute topographic maps in Howard, Prince Georges and Anne Arundel Counties (Fig. 1). The area selected for integrated pest management (treatment area) consisted of 59,519 ha, of which 29,760 ha was forested. The area selected for operational suppression (comparison area) consisted of 70,797 ha, of which 28,319 ha were forested. The physiography of the region is coastal plain with a predominant oak-hickory forest type.

Project Components

Survey and monitoring

The survey and monitoring system used in 1983 to delimit a project area was intensified in 1984 with the utilization of a greater number of grid points and 1-km^2 cells. At each accessible 1-km fixed grid point, a standard USDA milk carton pheromone trap containing a Hercon wick with 0.5 mg (+) disparlure and a slow release Vapona strip was placed on a branch at least 3m (6 ft) from the bole of an overstory tree or on a branch of an understory tree.

Life stage sampling points consisting of two 15 by 23 cm (6 by 9 in) beige plastic flaps (Almac Plastics, Baltimore, MD) were placed one on the north and south sides of 10 preferred host trees (20-36 cm dbh) surrounding the pheromone trap coinciding with every fourth grid point. Late-stage larvae used the plastic flaps as resting niches (McManus and Smith 1984). The flaps served as a relatively inexpensive and permanent alternative to burlap bands for collecting larvae, pupae and egg masses and their associated natural enemies (Reardon 1976). The relative abundance of life stages provided phenological data for the initiation of intervention activities and estimation of year-to-year population trends.

Of the potential 1850 fixed-grid points within the project area, 1647 points were usable in terms of having the conditions specified by the committee. Field personnel placed the male moth pheromone traps at the grid points in June, and in September removed and counted the moths. A sufficient quantity of pheromone traps and wicks were purchased in 1984 for use that year and for the remainder of the project to minimize known year-to-year variation in production sources and quality. Field personnel placed the traps at the same locations each year. Personnel implemented more intensive grids and surveys in localized areas within the 1-km^2 cells to delimit populations.

When personnel placed the traps, they collected data (e.g., tree species, crown condition) to determine the susceptibility of the surrounding forest stand to defoliation using methodology developed by Valentine and Houston (1984). An average susceptibility was also calculated for each 1-km^2 cell.

In fall and winter, field crews surveyed each fixed grid point and adjacent 1-km^2 cells to estimate egg mass densities. Those grid points with pheromone traps that captured more than 200 male moths and their associated cells were given first priority for egg mass surveys. Within the 1-km^2 cells, crews selected survey sites to favor preferred habitats: one 0.01-ha (0.025 acre) plot at each grid sampling point, four to eight 0.01-ha plots in forested areas, or four to six 0.04 ha (0.1 acre) plots in forested residential communities (Kolodny-Hirsch 1986). Crews collected egg masses at a subset of cells to provide viability data. To determine defoliation, project personnel conducted ground surveys and reviewed high altitude optical-bar photography of the project area.

Decision making

The committee decided the need for and selected intervention activities on the basis of a review of the following: egg mass and male moth density and trends; size and proximity of the infestation to other infested areas; stand susceptibility and percent defoliation; environmental sensitivity; social and economic value; and land use. The Maryland Department of State Planning provided MAGI data for vegetative cover types, natural soil groups, and land use and land cover. These data were reformatted as a predominant type for each category within each

of four equal subunits per 1-km^2 cell and for each grid point, to produce comparable profile maps. Areas of primary concern such as watersheds, sites with high recreational values, stands serving as centers of infestations, and highly susceptible or valuable timber stands were identified.

The committee made the following management decisions based on associated criteria for each fixed grid point and adjacent 1-km^2 cells within the treatment area each year: no action, preventive action or suppressive action.

> *No action* - Gypsy moth population density was low ($\leq$25 EM/ha); the trend (n/n-1) was stable or decreasing population($\leq$1); and other data (e.g., stand susceptibility to defoliation, proximity to other infested areas) indicated low potential for spread or impact (nuisance created by caterpillars). Under this decision, only surveillance activities were conducted.
>
> *Preventive action* - Population densities were low ($\leq$25 EM/ha); the trend was increasing population (>1) or population densities were moderate (26-250 EM/ha); and other information indicated high risk of spread or impact (nuisance or defoliation or both). This type of action was designed to slow the expansion of populations.
>
> *Suppressive action* - Population densities were high (>250 EM/ha); the trend was stable or increasing population; and other information indicated any risk of spread or impact.

The criteria developed for use by the Maryland Department of Agriculture during the cooperative suppression program were followed within the comparison area: (1) at least 10 ha (25 acre) of contiguous woods with at least 50 percent preferred host trees and at least 50 percent canopy cover of dominant trees; (2) populations not declining dramatically; and (3) at least 621 EM/ha.

Intervention

The aerial application of the entomopathogenic bacterium Bacillus thuringiensis kurstaki (Bt) was the major intervention tactic implemented in both project areas. Bt was the preferred insecticide due to its minimal effect on nontargets (except some Lepidoptera), short-term persistence and acceptance by the general public. It was applied using several formulations in one application at 30 BIU/ha(12 BIU/acre) and application rates of 7.1 or 9.3 L/ha (96 or 128 oz/acre). The aerial application of Bt was used alone or in combination with augmentative releases of the parasites Glyptapanteles flavicoxis (Marsh) and Cotesia melanoscelus (Ratzeburg) (Korean strain) or Luretape GM (Hercon Environmental, Inc., York, PA) at 50g AI/ha (20g AI/acre).

The aerial application of the insect growth regulator diflubenzuron (Dimilin®) in the treatment area was restricted to the following conditions: gypsy moth densities were greater than 621 EM/ha; population trends showed at least a tenfold increase over the previous year; and risk of impact was high. Diflubenzuron was aerially applied using the Dimilin 25W formulation at an application dose of 41.4 g /ha (0.5 oz AI/acre), and rate of 9.3 L/ha (1 gal/acre).

The ground application of diflubenzuron and bendiocarb (Ficam®) was restricted to isolated high value ornamental trees with at least 20 EM/tree. These insecticides were applied to entire trees using hydraulic equipment at an estimated 3 to 5 days before eggs started hatching. The 25W formulation of diflubenzuron was applied at the registered dose of 41.4 g/ha (0.5 oz AI/100 gal/acre), and the Ficam 76WP formulation of bendiocarb was applied at 0.22 L/ha (3 oz AI/100 gal/acre).

Evaluation

Gypsy moth life stages and variable data associated with habitat were collected by the MD-IPM Project field crews at the 1-km grid points, within 1-km^2 cells, and within specific treatment areas. These data were summarized for each year and compared between years to assess the broad implications of using an IPM approach versus a suppression approach.

The Survey Research Center at the University of Maryland conducted a telephone survey using a pretested questionnaire of Maryland residents who lived in an area (Cecil and Frederick Counties) where gypsy moth infestations and public control projects were conducted or ongoing. The objective of this survey was to determine homeowner willingness to support an IPM versus suppression approach for managing gypsy moth.

Public Involvement and Information

The University of Maryland Cooperative Extension Service and the MDA were responsible for informing the public about the project. These agencies initiated a public information program that included publishing a monthly newsletter, producing a leaflet entitled "Maryland IPM Gypsy Moth Project," and scheduling meetings and workshops to keep county agents informed of the project's progress. The MDA developed a pictorial display and a slide presentation about the project for use at meetings.

Agency personnel contacted individual property owners within the treatment and comparison areas for approval before establishing grid sampling points and implementing any intervention activity.

The committee organized a symposium in Annapolis, MD on the MD-IPM Project. Representatives from various State, Federal, political, and environmental groups attended. The project was described at numerous local, regional, national, and international meetings. Target audiences included both the public and private sectors.

Project Accomplishments

Database management

Since the MD-IPM Project was a pilot effort, all of its components were evaluated and updated yearly. This process was critical to assure immediate project success as well as to provide a basic structure for future IPM projects. The MD-IPM Project emphasized management of data, refinement of survey and monitoring techniques, and development of intervention activities for managing a wide range of population densities.

Life stage and other supportive data were collected yearly at 1,647 fixed-grid points and within 1,647 1-km^2 cells. For the first 3 years of the project, the data were recorded by hand onto standard forms and manually entered into a computerized database. This process did not allow sufficient time for error checking, processing and review of the data before developing year-to-year plans; therefore, a prototype system using optical scanning technology was developed by the Entomology Department at Virginia Polytechnic Institute and State University (VPI&SU) (Appendix III). This system was rapid, cost efficient, and reduced the number of recording errors. Once data were assembled, commercially available software (e.g., Oracle®) was used to facilitate decisionmaking by providing an interactive capability.

In cooperation with VPI&SU, all computer-based activities were conducted on a mainframe, and computer-aided mapping was used to assist in making faster, more-informed decisions. It provided, in part, male moth and egg mass densities and trend data between the 1-km grid points, which were all displayed on Mylar overlays. The simplest type of representation, a posting (Fig 2), showed UTM coordinates of sample sites and results of male moth and egg mass surveys. Also, using several types of interpolation algorithms, density and trend data were displayed as a two-dimensional contour map (lines of equal value) (Fig. 2) and three-dimensional block diagram (or transect) surfaces by interpolating between grid points (Fig. 2) (Roberts et al. 1993). Estimated values at unsampled sites were determined from values at neighboring sites and their distances from the point being estimated. Male moth data were contoured at intervals of 25 moths for all maps and egg mass data at intervals of 10 EM/ha. Surface II Graphics System (Sampson 1978) were used to perform interpolations and to generate maps. Because they depended upon interpolated data, both the contour map and the block diagram were essentially qualitative. Contour maps were somewhat more quantitative than were block diagrams (map data in a relative fashion) as the maps depicted spatial data as lines of equal value. Interpretation was most meaningful if postings, contours, and transects were compared for each area.

The committee compared and analyzed the actual male moth data collected on the 1-km grid with that data generated at 1-km points using 2- and 3-km grid data as input. These data were compared using 10-, 25-, 50- and 100-moth contour categories. When the 50-moth and 100-moth contour categories were used, the 2-km grid could predict 75 percent and 83 percent of the time at or above these categories, as for the 1-km grid. The predictive percentages for the 3-km grid were not much lower than for the 2-km grid. Most of the approximately 25 percent error in prediction occurred in noncontinuous habitats (e.g., urbanized areas, golf courses). Therefore, a more intensive grid spacing (less than 1-km) is needed in these or sensitive habitats.

Intervention activities

Historically, aerial application of Bt was used to suppress high-density gypsy moth populations. Its use against low-to moderate density populations was minimal and usually associated

with attempts to eradicate isolated populations using multiple applications. Since the MD-IPM Project area included the leading-edge of the gypsy moth infestation, the committee considered the operational use of Bt alone and in combination with other tactics against these population levels as experimental. Therefore, the criteria for its use in combination with other tactics were evaluated yearly. Since gypsy moth-specific intervention tactics (e.g., Gypchek, inherited sterility, mating disruption) were in the initial stages of development and only a few successfully used to eradicate isolated low-density populations, emphasis was placed on developing these tactics for operational use. To conduct these evaluations, replicated small (<15 ha) plots were established in areas with appropriate host population levels outside the treatment and comparison areas so as not to confound the operational treatment efforts. The following intervention materials and tactics were evaluated: Gypchek, Bt, inherited sterility, mating disruption, parasites, entomogenous nematodes, and systemic insecticides.

Gypchek - Gypchek is the formulated nucleopolyhedrosis virus (NPV), which is specific to gypsy moth and usually associated with the natural collapse of dense populations (Doane and McManus 1981). Before the MD-IPM Project, Gypchek was in the initial stages of development, results were erratic and its effectiveness was limited mainly by formulation problems (Reardon and Podgwaite 1992). The MD-IPM Project initiated, in cooperation with the Forest Service's Northeastern Forest Experiment Station, developing an improved formulation (including a higher dose) and evaluating its efficacy in both ground and aerial applications.

A series of field evaluations were conducted whereby Gypchek was applied to egg masses (prior to egg hatch) and the surrounding trees using mist blower and hydraulic equipment to initiate an epizootic at low population densities. These efforts were unsuccessful due, in part, to minimal NPV persistence.

The ground application of Gypchek using hydraulic equipment against first and second stage gypsy moth larvae reduced moderate to dense populations and protected foliage and was recommended for operational use (Podgwaite et al. 1991).

The aerial application of Gypchek to suppress moderate to dense populations involved a series of yearly evaluations of various formulations, sunscreens (e.g., folic acid, Dipel 6L carrier), dosages, rates and numbers of applications (Podgwaite et al. 1988, 1992). These evaluations led to the standard formulation and application parameters recommended for use since 1987: 18.7 L/ha (2 gal/acre) per application, two applications 3 to 5 days apart, 5 X 10^{11} polyhedral inclusion bodies (PIB's) per acre, against first and second stage larvae, and Orzan LS as the sunscreen. Even though the aerial application of Gypchek successfully reduced populations and protected foliage, limited production of Gypchek prevented its use as an operational tactic during the MD-IPM Project. The MD-IPM Project, however, provided the stimulus for several companies to attempt commercial production of Gypchek.

In 1984 and 1985, Ma et al. (1984) evaluated an enzyme-linked immunossorbent assay (ELISA) technique using polyclonal antibodies to quantify NPV incidence in gypsy moth life stages. The ELISA technique, however, did not have the sensitivity to quantify levels of gypsy moth NPV and only detected its presence. A subset of aerially applied Gypchek plots was used as part of a study to determine the short-term effects of Dimilin, Bt and Gypchek on natural enemies of the gypsy moth. In general, numbers of the braconid gypsy moth parasite Cotesia melanoscelus were reduced in Gypchek treated plots, increased in Bt treated plots, and were comparable in Diflubenzuron treated plots to control plots. Application of either Bt or Diflubenzuron resulted in a decrease in incidence of NPV compared to control plots (Webb et al. 1989).

Bacillus thuringiensis (Bt) - Since various dosages, rates and formulations of the HD-1 strain of Bt were being evaluated as part of other operational programs, the MD-IPM Project emphasized a newly identified strain of Bt isolated from the spruce budworm. The NRD-12 strain, formulated as SAN-415 SC 32LV (Sandoz, Inc., Wasco, CA) was evaluated, in cooperation with the Forest Service's Northeastern Forest Experiment Station, at one and two applications against a range of low to moderate population densities (Dubois et al. 1988). The efficacy results were favorable for reducing populations (based on egg mass counts) and protecting foliage; and did not differ significantly between one and two applications. These data were used to support the registration of the NRD-12 strain for control of gypsy moth. Also, data were collected to substitute the lack of Bt carry-over effects in the surviving host population: the fecundity (number of eggs per mass) of the surviving females in the treated plots was not adversely affected nor did the percentage of eggs that hatched differ from that of the previous generations.

Inherited sterility - The sterile insect technique for gypsy moth involves two approaches: the classical approach of releasing totally sterile insects or the inherited sterility approach (Reardon and Mastro 1993). Releasing large numbers of totally sterile males to control low-density gypsy moth populations was initiated in 1977 to eradicate isolated infestations. Due to limited laboratory production and high costs, this approach evolved into the inherited sterility approach of releasing substerilized males or F1 sterile eggs (substerile males crossed with untreated females). Just before the start of the MD-IPM Project, several eradication efforts using releases of F1 sterile eggs against low-density isolated populations were successful. These efforts generated a lot of interest in expanding the use of inherited sterility against low-density populations along the leading-edge of the gypsy moth infestation.

The MD-IPM Project initiated efforts in cooperation with APHIS, ARS and the Forest Service's Northeastern Forest Experiment Station, to evaluate the aerial and ground release of F1 sterile eggs over 3 years (1984-86). A 50:1 ratio of sterile to wild egg masses was used for all studies. In 1985 and 1986, numerous problems were encountered: severe mortality of first and second stage F1 larvae, poor synchronization of hatching with wild populations, underestimation of wild populations, and increase in density of wild egg masses in treated plots. Also, evaluation of this tactic required intensive field collections and laboratory processing of various life stages with associated high costs and time delays in obtaining efficacy results. After 3 years of effort and apparent lack of efficacy, additional research was still needed concerning competitiveness of F1 larvae and adults, methods for sampling immatures and adults, and synchronization of releases with ferals. For these reasons, the committee decided not to continue evaluating this tactic as it would not be ready for operational use by the end of the project.

Mating disruption - The synthetic formulation of the chemical attractant of the gypsy moth female (disparlure) has been used in attempts to disrupt communication and mating. Disparlure is most effective against low-density populations (<25 egg masses/ha) (Schwalbe et al. 1983). In addition, several State Departments of Agriculture were using the ground placement of racemic disparlure as Luretape® GM (Hercon Environmental Inc.) to suppress low-density isolated populations in front of the leading-edge of gypsy moth infestation. Luretape was commercially available in rolls of laminated plastic impregnated with racemic disparlure which was removed in 5 cm by 5 cm sections and tacked onto the boles of trees located along transect lines (i.e., 100 points per ha using a 10-m grid). Each roll could treat approximately 2 hectares (5 acres) when applied at a dose of 50g AI/ha (20g AI/acre). Since efficacy results were promising on the basis of male moth captures but erratic on the basis of egg mass surveys, Luretape was used minimally and only as a follow-up tactic to the aerial application of Bt.

The MD-IPM Project initiated efforts to evaluate Luretape as an individual intervention tactic on a series of replicated plots over several years (Kolodny-Hirsch et al. 1990). Luretape was

manually applied in 1984, 1986 and 1988 at a dose of 50g AI/ha. Significant reductions in male trap catch and mating clearly demonstrated that the disruptant remained biologically active for two seasons. Nevertheless, egg mass surveys showed that the repeated application of Luretape failed to maintain gypsy moth populations at low levels over the 5-year period. The lack of efficacy was attributed, in part, to inadequate mating disruption during peak male activity, ineffective permeation of disruptant throughout the canopy of trees (based on mating of monitor females placed at 6.5 m (20 ft) above ground strata) and close proximity of treated woodlots to moderate-level gypsy moth populations. These results suggested the need for higher doses of disparlure and better vertical distribution of the pheromone.

Parasites - The attempt to establish exotic parasite species was not emphasized because the Maryland and New Jersey Departments of Agriculture (in cooperation with APHIS) had reared and released numerous species in Maryland during 1972-80. Also, most of the parasite species established in the generally infested area (e.g., Cotesia melanoscelus, Compsilura concinnata, Parasetigena silvestris, Brachymeria intermedia and Phobocampe unicincta) were recovered in the treatment area or bordering northern counties in 1983. In 1984 and 1985, The exotic species, G. flavicoxis, Rogas lymantriae and C. melanoscelus (Korean strain), were released within the treatment area. Rogas lymantriae was reared on gypsy moth and tussock moth larvae and released as cocoons, adults and parasitized hosts throughout the season. In 1987, the polyphagous pupal parasite Coccygomimus disparis was released within the treatment area, as this newly released exotic species was being recovered at numerous sites in New Jersey and Pennsylvania. None of the exotic species released within the project areas was recovered beyond the original site and year of release.

The augmentative release of established species was not emphasized due to low parasitism rates throughout the treatment area and a general lack of habitat and life history data concerning established species. Since laboratory facilities were available at the Maryland Department of Agriculture and techniques developed to maximize production of C. melanoscelus (Kolodny-Hirsch 1988), augmentative releases of the Korean strain of this species were attempted in small (<3 ha) isolated woodlots. The Korean strain was selected because it makes a mat of silken threads around its cocoon for protection (in theory) from hyperparasites. The release of approximately 12,000 females per woodlot increased rates of parasitism by Cotesia spp in the treated versus the control woodlots, but population reduction as determined by intensive egg mass surveys was not significantly different (Kolodny-Hirsch et al. 1988).

In 1986, a study was initiated in the Piedmont, mountain and coastal plain areas in Maryland to determine the relative abundance and seasonality of the hyperparasites associated with the Korean and the established strains of C. melanoscelus. In general, the cocoons of both strains of C. melanoscelus were severely impacted by numerous species of hyperparasites which were active throughout the overwintering season (Wieber et al. in press).

Entomogenous nematodes - Early in the MD-IPM Project the committee identified the need to develop an intervention tactic that could be used in residential areas to protect individual trees from defoliation, that was adaptable for homeowner use and would not involve the use of chemical insecticides. Entomogenous nematodes have provided control of several ground inhabiting and tree boring pest species, although results for defoliators were inconsistent (Gaugler 1981, Kaya et al. 1981, Kaya and Reardon 1982). The nematodes actively search out their hosts and enter their body openings whereby a bacterium kills the host by septicemia. Two species of nematodes, Steinernema carpocapsae and S. feltiae, available commercially (Biosys, Palo Alto, CA) at low cost, were applied to cloth-lined burlap and plastic bands around tree boles using a hand-held pump sprayer. The results were highly variable between trees primarily due to the nematodes' need for a humid environment (Reardon et al. 1986). Nematodes were not applied operationally to individual trees in residential areas.

Systemic insecticides - Mauget Systemic Units® (Mauget Co.,Inc., Burbank, CA) and ACECAPS (Creative Sales, Inc., Fremont, NE)containing the systemic insecticide acephate were evaluated as a tactic to protect high value individual trees (Reardon 1984). Both methods provided a portable, closed system that minimized loss of the insecticide into the environment. The ACECAPS implanted into individual trees reduced the gypsy moth population significantly and protected foliage for the year of treatment (Webb et al. 1988). Year-to-year use on the same tree was not recommended (Reardon and Webb 1990). Also, since some internal and external wound response was evident on most of the Quercus species evaluated, this technique was not recommended for use in residential areas.

Population monitoring and surveying

Male moths - The committee used male moth data collected at the 1-km grid points to determine the priority for surveying for egg masses at 1-km points and 1-km^2 cells. Traps that captured more than 200 male moths provided a good indication that egg mass(es) could be located in the associated 1-km^2 cells. The male moth survey data were grouped into categories for each year and displayed for both the IPM (treatment) and comparison (control) areas (Fig. 3). The mean and range of male moths captured per trap each year were as follows:

	YEAR									
Male moth/trap	1983		1984		1985		1986		1987	
	IPM	Comp.	IPM	Comp.	IPM	Comp.	IPM	Comp.	IPM	Comp.
$\bar{x}$	175	181	104	107	88	96	163	141	507	428
range	0-1734	0-1468	0-1021	0-1174	0-1040	3-1057	0-1434	0-928	5-1530	0-1519

In 1983, gypsy moth populations were low, as the mean member of male moths captured per trap was less than 200, and approximately 70 percent of the traps captured less than 35 moths per trap. In 1984 populations continued to decline, and in 1985 an additional decrease in populations was recorded. Although moth captures differed over these 3 years, the spatial characteristics of trap catch were similar for all years, with numbers generally being low (Fig. 3). In 1986, populations increased to approximately 1983 levels which were still low. In 1987, regional increases were recorded in both the IPM and comparison areas (Fig. 3).

In 1984, mean trap catch represented a 41 percent decrease (as compared to 1983) in male moths per trap in both the IPM and comparison areas (Fig. 4). In 1987, regional increases were recorded in both the IPM and comparison areas as male moth captures increased (as compared to 1986) at 96 percent of the sites.

Highest captures as well as the greatest variation in captures of male moths were in the western and in the northeastern sections of the project area in all years.

Egg masses - Before the MD-IPM Project, several sampling methods were commonly used to estimate egg mass density, although their relative precision and cost had not been evaluated. To select a standard method for sampling gypsy moth egg masses, Kolodny-Hirsch (1986) evaluated several established methods in predominantly oak woodlots on the Eastern Shore in Maryland. The 0.01-ha (0.025A) plots were superior to the other methods in cost and precision, and sequential sampling plans were developed with fixed levels of precision for use within the project areas.

The mean number of egg masses per hectare (EM/ha) was calculated by averaging the numbers at the four grid points and within the 1-km^2 cell, and placing the data into a category (Fig. 5).

From 1983 through 1986, fall egg mass surveys indicated low populations. In 1984, average EM/ha/cell decreased by 21 percent (5.8 vs 4.6) in the IPM area and by 2 percent (5.6 vs 5.5) in the comparison area (Fig. 6). Numbers of egg masses in the IPM area averaged 4.2 (1985) and 9.9 EM/ha/cell (1986) and in the comparison area averaged 2.6 (1985) and 3.9 EM/ha/cell (1986), although crews continued to find "hot spots" (Fig. 6). These higher egg mass populations were generally found within residential areas as opposed to uninhabited forested areas.

In 1987, egg mass numbers increased on a regional basis (Fig. 5): the average was 139 EM/ha/cell in the IPM area and 84 in the comparison area, with 95 percent of the sites showing increases over 1986 populations (Fig. 6). When the mean numbers of egg masses per hectare per cell were grouped on the basis of management decision categories, it was not until 1987 that approximately 85 percent and 3 percent of the cells in the IPM and comparison areas would be considered for treatment:

$\bar{X}$ EM/ha	Percent per Category									
	1983		1984		1985		1986		1987	
(category)	IPM	Comp.	IPM	Comp.	IPM	Comp.	IPM	Comp.	IPM	Comp.
0	78.9	87.4	71.1	81.4	7.8	84.3	64.0	78.1	12.9	38.1
1-5	6.3	4.2	11.5	7.8	4.8	3.4	8.1	5.2	2.5	3.1
6-25	9.9	6.8	13.8	8.3	12.6	10.0	18.6	13.5	13.2	16.1
26-621	4.8	1.4	3.6	2.4	4.8	2.4	9.3	3.2	66.7	40.1
> 621	0	0.1	0	0.1	0	0	0	0	4.7	2.6

In 1984, a total of 500 gypsy moth egg masses was collected with an average of 633 eggs per mass in the IPM area and 584 eggs per mass in the comparison area. In January and February 1985, egg masses collected in the treatment areas averaged 614 eggs per mass, and in the comparison area averaged 645 eggs per mass. Condition of eggs in treatment and comparison areas was as follows:

	IPM Area		Comparison Area	
Egg Condition	1984	1985	1984	1985
	Percent			
Viable	55	61	64	70
Nonviable	22	10	9	11
Parasitized	23	29	27	18

These data indicated that populations in the IPM and comparison areas were of relatively poor quality across both years. Similar data were recorded for egg masses collected in both project areas in 1986 and 1987. Unfortunately, we were not able to use these data to predict population trends nor to identify key mortality factors operating against these low level populations.

In 1987, gypsy moth populations increased dramatically on a regional basis and continued to increase as evidenced by the 1988 male moth and egg mass survey data sets (Fig. 7). The rate of increase (1987-1988) for male moths and egg masses is documented in Fig. 8.

Pupae - Field crews monitored 970 bark flap sites in both 1983 and 1984, and observed no larvae or pupae from approximately 90 percent of the sites. At sites where crews observed pupae, plastic flaps had a preponderance of female pupae in both years. From 1985 through 1986, crews counted only pupae under plastic flaps, and numbers continued to be low due to low population levels. After 1986, the pupal counts were discontinued due to associated high costs and low R-square values (e.g., 0.03, 0.07) relative to numbers of associated egg masses under plastic flaps.

Population management

Over the first 3 years of the MD-IPM Project, the treatments included these: aerial application of Bt, aerial application of Bt followed by ground application of Luretape, aerial application of Bt followed by release of parasites, aerial and ground application of diflubenzuron, and ground application of Turcam (Table 1, Fig. 9). In 1986 and beyond, the committee recommended only two treatments as effective: aerial application of Bt alone or aerial application of diflubenzuron.

In the comparison area, Bt was aerially applied only to populations >621 EM/ha on a total of 739 ha. Since Bt was aerially applied against much lower host densities within the treatment area, it was applied alone or in combination to a total of 2,445 ha. The average block size over the 5 years of the project was 41 ha in the treatment area and 68 ha in the comparison area.

From 1983 through 1985 within the treatment area, aerial application of Bt reduced the population by an average of 83 percent, Bt and Luretape reduced the population by an average of 71 percent, and Bt followed by the release of parasites reduced the population by an average of 80 percent. In 1983 through 1985 within the comparison area, aerial application of Bt reduced the population an average of 58 percent. Based on these data, the Bt combination treatments could not be justified over Bt alone; therefore, the combination treatments were discontinued. In 1987, those populations treated with Bt increased an average of 15 percent within the treatment area but were reduced an average of 24 percent in the comparison area. Population quality probably had a significant influence on the success of treatment with Bt, as populations were naturally declining in 1983 - 1985 and regionally increasing in 1987.

Throughout the first 4 years of the project, gypsy moth populations remained fairly constant at low levels in both treatment and comparison areas. In 1987 populations increased significantly on a regional basis; therefore, the MD-IPM Project was extended for 1 year, through 1988. A much reduced budget was made available for the 1988 season with priority given to: integrating and evaluating all updated project components, maintaining the survey and monitoring system, and intervening against populations greater than 100 EM/ha in only three 7.5-minute topographic quadrangles (Round Bay, Odenton and Relay) (Fig. 10). These quads were a logical choice because the majority of the intervention applied since 1984 had taken place in these areas. In addition, all areas within the comparison area with populations >621 egg masses/ha were treated to maintain a regional management of gypsy moth populations.

The committee proposed the location of treatment areas based on computer-generated contours of egg masses with subsequent ground truthing by field crews. A total of 3,164 ha in the Round Bay, Odenton and Relay quads in the treatment area had populations greater than 100 EM/ha, although only 377 ha had populations greater than 621 EM/ha. A total of 611 ha in five quads within the comparison area had populations greater than 621 EM/ha. All areas were treated with the NRD-12 strain of Bt using a dose of 30 BIU/ha and an application rate of 7.9L/ha. In the treatment area, those populations treated with Bt averaged an 85% reduction across 15 plots. After the same treatment in the comparison area, populations averaged a 10 percent reduction across 15 plots. The male moth and egg mass survey data for 1988 (Fig. 7) indicated that populations continued to increase; in fact, regional increases were recorded (Fig. 8)

Defoliation surveys detected no defoliation attributable to gypsy moth within the treatment or comparison areas from 1983 through 1987. In 1988, crews reported 39 ha of defoliation in the treatment area and none in the comparison area.

The forest stand at each UTM coordinate and predominant stand within each 1-km^2 cell were classified as resistant or susceptible to defoliation. Approximately 15 percent of the UTM coordinates and cells were classified as susceptible to defoliation, although due to low-level populations of gypsy moth we were not able to compare the predicted rating with actual defoliation data.

Funding

Forest Service costs

The Forest Service budget for the MD-IPM Project averaged $441,200 per year, with $374,000 allocated for direct costs and $67,200 in indirect charges, over the 5-years of the project. Project managers used approximately 76 percent of the operating budget for salaries. Of the salary expenditure, 36 percent was allocated to contractual field and laboratory personnel. Transportation costs for the contractual staff were 9 percent and contracts for services and supplies were an additional 9 percent of the operating budget.

The operational cost of aerially applying Bt averaged $25.12/ha (range $9.72/ha to $37.51/ha), which included contracting, insecticide and ground support. The total operational cost for ground application of Luretape averaged $63.00/ha, which included $49.50/ha for Luretape and $13.50/ha for labor.

The methods improvement projects were an important component of the MD-IPM Project although associated costs were often high due to intensive survey and monitoring to estimate low-level populations:

Year	Tactic	Cost
1985	Sterile F1	$49,219
1986	NRD-12	$34,766
1986	Gypchek	$31,295
1987	Gypchek	$35,021

Surveys for egg masses were conducted from September through March, and personnel costs were approximately $39,000 per year. Travel and supply expense for the egg mass surveys totaled $12,000 per year. In the comparison area, an average of 625 1-km grid points and associated cells were surveyed per year for egg masses. A 20 person field crew needed an average of 672 hours to conduct the actual surveys and 235 hours to drive to and from the sample sites. The average cost to conduct egg mass surveys was $7.00 per 1/40-acre plot and $14.50 per residence.

Labor charges for placement and removal of pheromone traps averaged $11,000 from June through August with an additional $11,000 for travel and supplies per year. The average cost was approximately $13.35 per trap.

In 1983 and 1984, the average cost per year to place, maintain and monitor the plastic flaps for larvae and pupae was approximately $25,000 for wages and $8,000 for travel and supplies from April through mid-July.

Public willingness to pay

From July 18 to August 22, 1987, the Survey Research Center at the University of Maryland conducted a telephone survey to determine residents' willingness to pay to avoid defoliation, tree loss, and nuisance caused by the gypsy moth. The percentage of total respondents (603) who supported each ranking for these gypsy moth impacts and associated concerns was:

	Ranking		
Concern	Very Important	Somewhat Important	Not at all Important
Trees lose their leaves	81	18	1
Trees may die	95	4	1
Presence of dead or live caterpillars	43	35	22
Cost of Government control efforts	47	37	16
Cost of private control efforts	60	27	13
Health concerns regarding control efforts	73	18	9

The residents were presented with a situation depicting gypsy moth infestation and the damage that would be caused. Each respondent was then asked whether he/she would vote for a referendum enacting one of two scenarios for managing gypsy moth populations: the first concerned financing an aerial spray program when potentially defoliating populations were present (suppression spraying), and the second was a 5-year continuous IPM program. Each resident was presented with an initial cost per household; depending on the answer, he/she was asked for a response if the amount was higher or lower. The percentage of respondents choosing each initial cost per househould was:

		Per Household Price		
Approach	Response	$20	$45	$60
Suppression	vote for it	60	47	46
	probably not vote for it	10	16	17
	not vote for it	20	30	29
	do not know	10	7	8
	number asked this amount	202	201	200
IPM	vote for it	69	48	39
	probably not vote for it	10	15	20
	not vote for it	17	30	34
	do not know	4	7	7
	number asked this amount	199	200	204

The majority of the residents (60 and 69%) who supported suppression and IPM approaches respectively, were willing to pay $20 or less per household (one-time cost for suppression or yearly cost over 5 years for IPM).

Those residents who probably would not support either scenario stated that they could not afford it (31%), present taxes should cover it (32%), they did not want spraying (16%), and other (21%).

The residents were asked their opinion on different types of insecticides that could be used to manage gypsy moth. When asked about aerial spraying of chemicals, 30 percent opposed and 58 percent favored this scenario. When asked about aerial spraying of non-chemical/bacterial insecticides, 30 percent opposed and 53 percent favored this scenario. Those respondents who opposed the aerial application of chemical and non-chemical/bacterial insecticides were asked again if they knew that the insecticides would not harm humans:

	Insecticides	
Response	Chemical	Non-chemical
still opposed	46%	67%
now favor	51%	27%
other	3%	6%

The residents were asked their opinion concerning the ground application of chemical insecticides. Approximately 60 percent of the respondents were in favor and 29 percent opposed the ground application of chemical insecticides. Those respondents who were in favor of the ground application of chemical insecticides were asked to respond again if they knew that the cost for ground application was 3 times as much as for aerial application. A total of 54 percent now opposed, 35 percent still favored and 11 percent were not certain about ground application of chemical insecticides.

In an effort to summarize the residents' opinions concerning aerial spraying, they were asked at the end of the survey to provide a general response about aerially spraying <u>any</u> substance (25% opposed and 43% supported) and if an aerial spray project were conducted, which type of insecticide was preferred (60% non-chemical/bacterial and 11% chemical).

Summary

The MD-IPM Project provided an initial evaluation of a prototype IPM approach to managing populations of the gypsy moth along the leading-edge of gypsy moth infestation, from 1983 to 1987. During the first couple of years, however, it became clear that many of the project components, such as survey and monitoring, data management and intervention required additional updating on a yearly basis.

The survey and monitoring component of the project was the most critical, as it provided the basis for all management decisions. The male moth and egg mass data represented, at that time, the longest data set for fixed-plots over time. In fact, this project was the first attempt to use pheromone traps to monitor populations over a broad geographical area at density levels below those that have the potential to cause economic damage. Also, the 1-km monitoring grid provided the data to demonstrate that by placing traps on 2-km or 3-km grids and estimating captures at the 1-km intertrap sites, the number of pheromone traps placed in the field could be significantly reduced.

Natural regional declines in gypsy moth populations between 1983 and 1986 precluded a comparison of population dynamics over time across large acreages within the treatment and comparison areas. Since specific gypsy moth intervention tactics were not available for managing low-density populations, only the aerial application of <u>Bt</u>—alone or in combination with Luretape or parasites—was used operationally.

Major emphasis was placed on evaluation and development of gypsy moth specific intervention tactics. The project was responsible for bringing the ground and aerial applications of Gypchek and the aerial application of the NRD-12 strain of Bt into operational use. Also, the NRD-12 Bt evaluation provided the opportunity to document that there were not any carryover effects of Bt in the residual gypsy moth population. The project supported the first attempt to evaluate, using replicated plots, the use of F1 sterile eggs against leading-edge populations; entomogenous nematodes; and injection and implementation of systemics. Also, the evaluation of Luretape demonstrated its ineffectiveness as an individual tactic to suppress low-density populations and several State Departments of Agriculture discontinued its operational use. The project also supported the first efforts to quantify NPV persistence using an ELISA technique. The first augmentative release of the parasite C. melanoscelus (Korean strain) was supported by the project.

The data collection, management, and presentation techniques developed during the project represented a major prototype effort which relied on data base management and computer-assisted mapping technologies. These technologies were essential for timely presentation and review of data across the MD-IPM Project area. These systems were evolving along with the project; many of the most useful capabilities became available in the last 2 years of the project. No predictive models were available for use during the project.

The committee provided a mechanism whereby researchers, extension specialists, and implementors could interact to develop standardized management plans and produce a coordinated program over a broad geographical area.

The MD-IPM Project was a critical initial step in the continued development of an IPM approach to managing gypsy moth populations. It provided a prototype IPM approach for the Appalachian Integrated Pest Management (AIPM) Gypsy Moth Project.

Appendix I

Table 1. - Intervention Activities Applied within MD-IPM Project Area 1983-1987

	IPM AREA			COMPARISON AREA	
YEAR	TREATMENT	HECTARES	INDIVIDUAL TREES	TREATMENT	HECTARES
1983	Aerial Appl Bt	76	--	Aerial Appl Bt	103
1984	Aerial Appl Bt	450	--	Aerial Appl Bt	155
	Aerial Appl Bt/ parasite[1]	534	--		
	Inoculative release parasite[2]	2	--		
	Ground Appl Turcam[3]	--	15		
	Ground Appl Gypchek[3]	4	--		
1985	Aerial Appl Bt	563	--	Aerial Appl Bt	135
	Aerial Appl Bt/ parasite[1]	234	--		
	Aerial Appl Bt/ Luretape	74			
	Ground Appl DFB[4]	2	2		
	Ground Appl Turcam[3]	--	2		
	Aerial Appl DFB[4]	14			
1986	No Treatment	--	--	Aerial Appl Bt	102
1987	Aerial Appl Bt	514	--	Aerial Appl Bt	244
TOTALS					
	Aerial Appl Bt	1603	--	Aerial Appl Bt	739
	Aerial Appl Bt/ parasite	768	--		
	Aerial Appl Bt/ Luretape	74	--		
	Parasite	2			
	Aerial Appl DFB	14			
	Ground Appl Gypchek	4			
	Ground Appl Turcam	--	17		
	Ground Appl DFB	--	2		

[1]Augmentative release of Apanteles melanoscela (Korean strain)
[2]Cotesia melanoscela (Korean strain) and Glyptapanteles flavicoxis
[3]Applied against egg masses
[4]DFB = diflubenzuron

Appendix II

Figures 1 through 10 on the following pages.

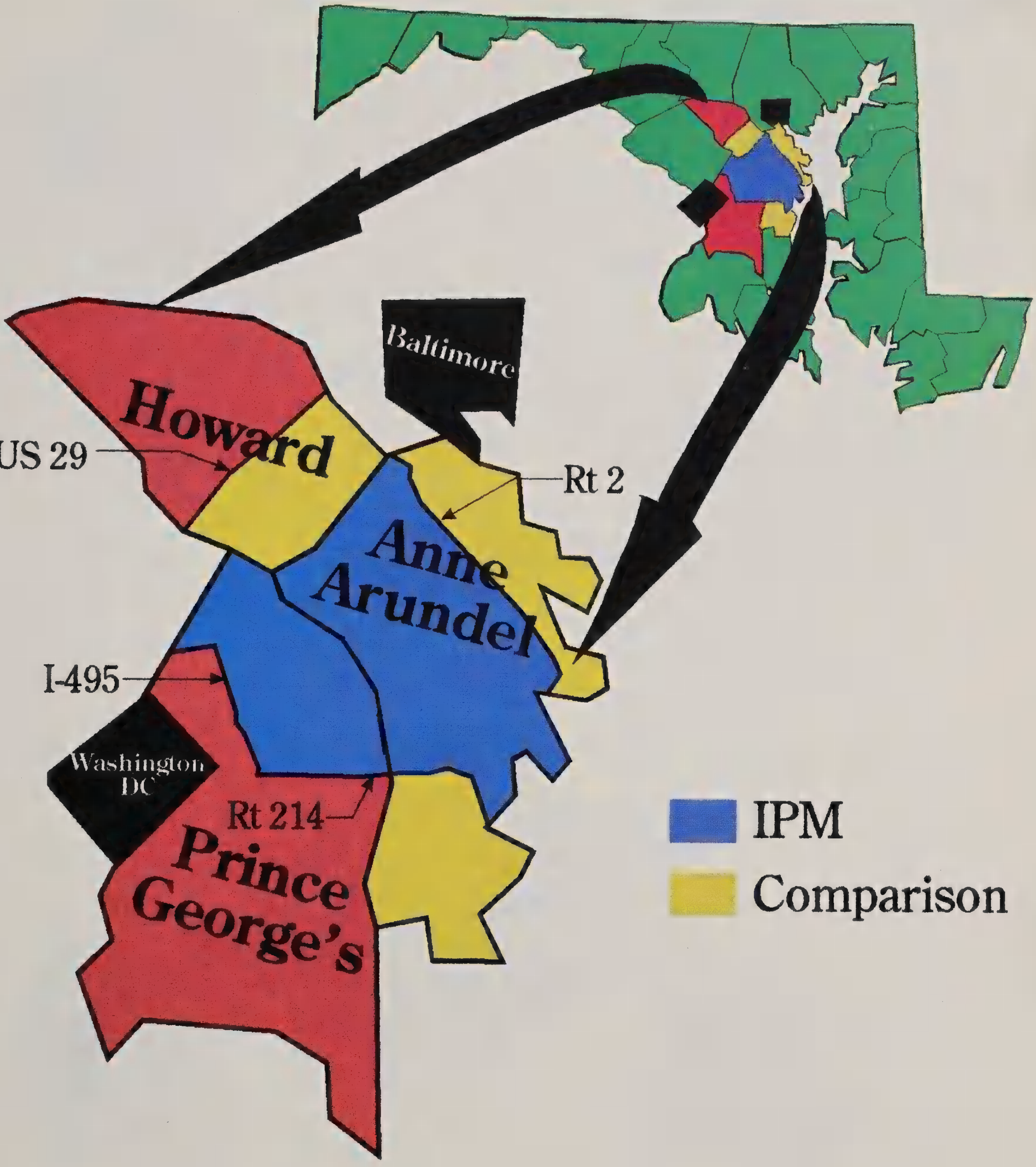


Figure 1: The Maryland Integrated Pest Management Gypsy Moth Project Area 1983-1987

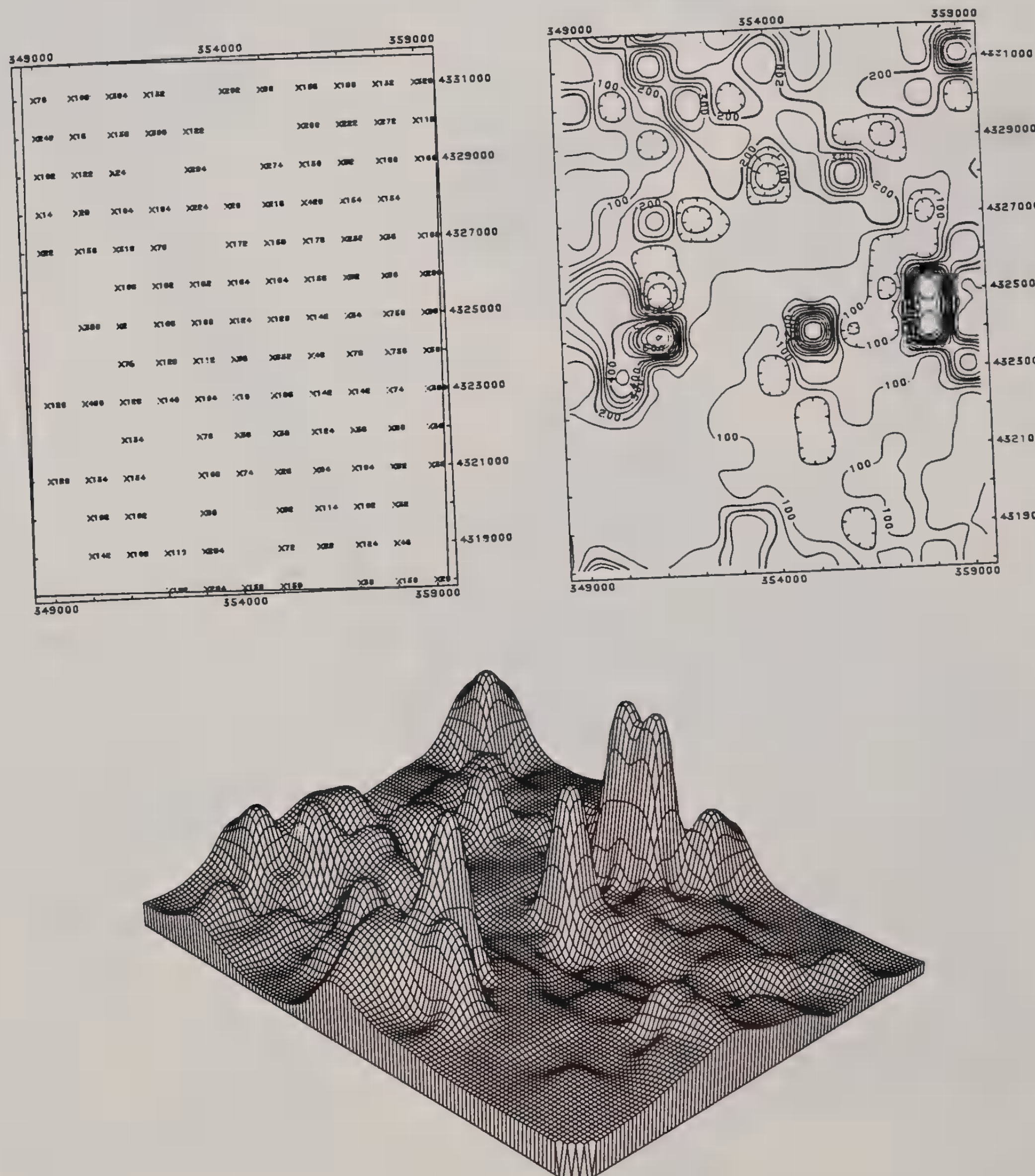


Figure 2: Posting, contour and orthogonal projection of 1986 gypsy moth pheromone trap catch, in increments of 100 moths, from a 7.5 mim. USGS quadrangle in MD-IPM Project.

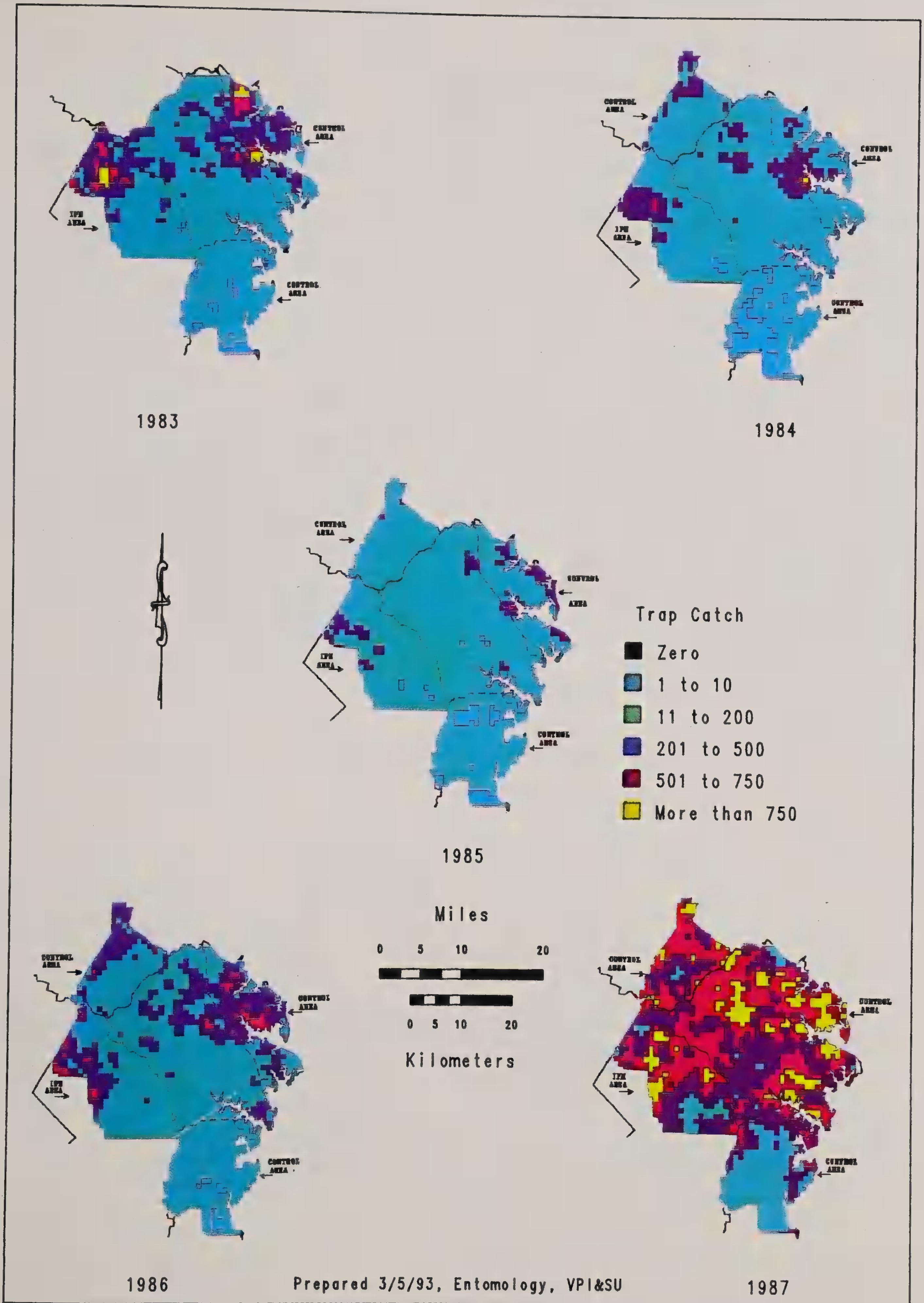


Figure 3: Male moth survey data 1983-1987

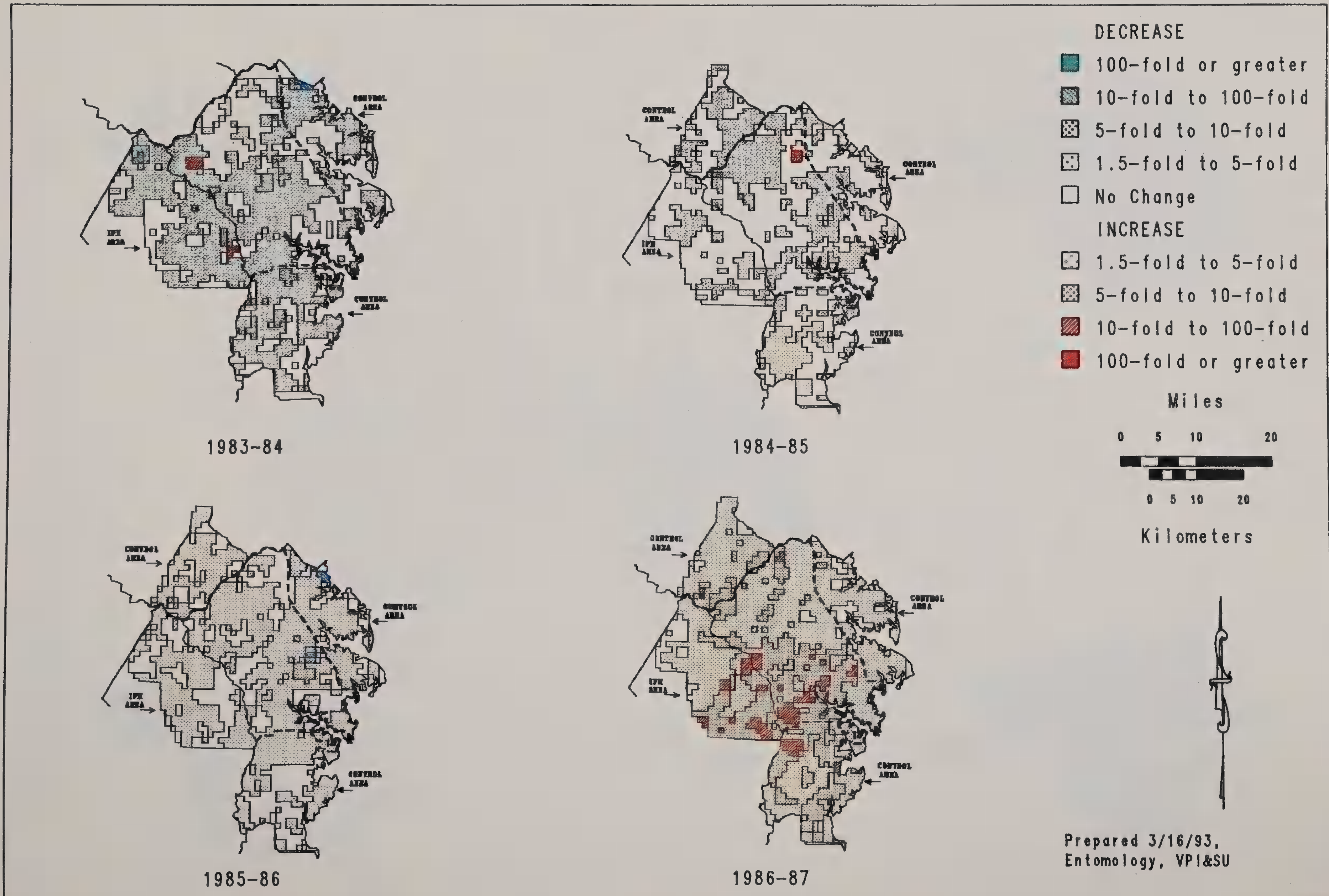


Figure 4: Change in male moth captures between years (1983-1987)

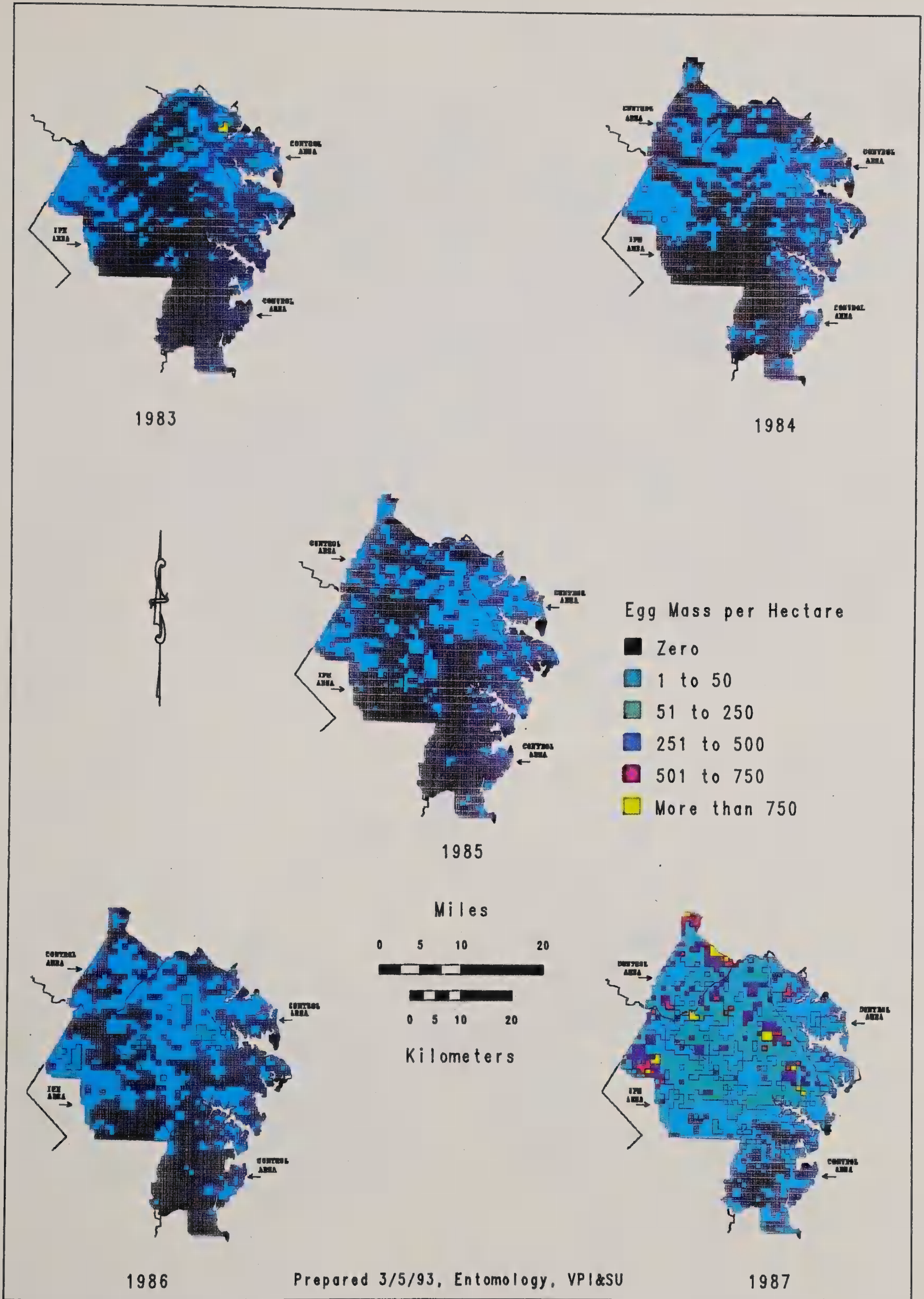


Figure 5: Egg mass survey data by year (1983–1987).

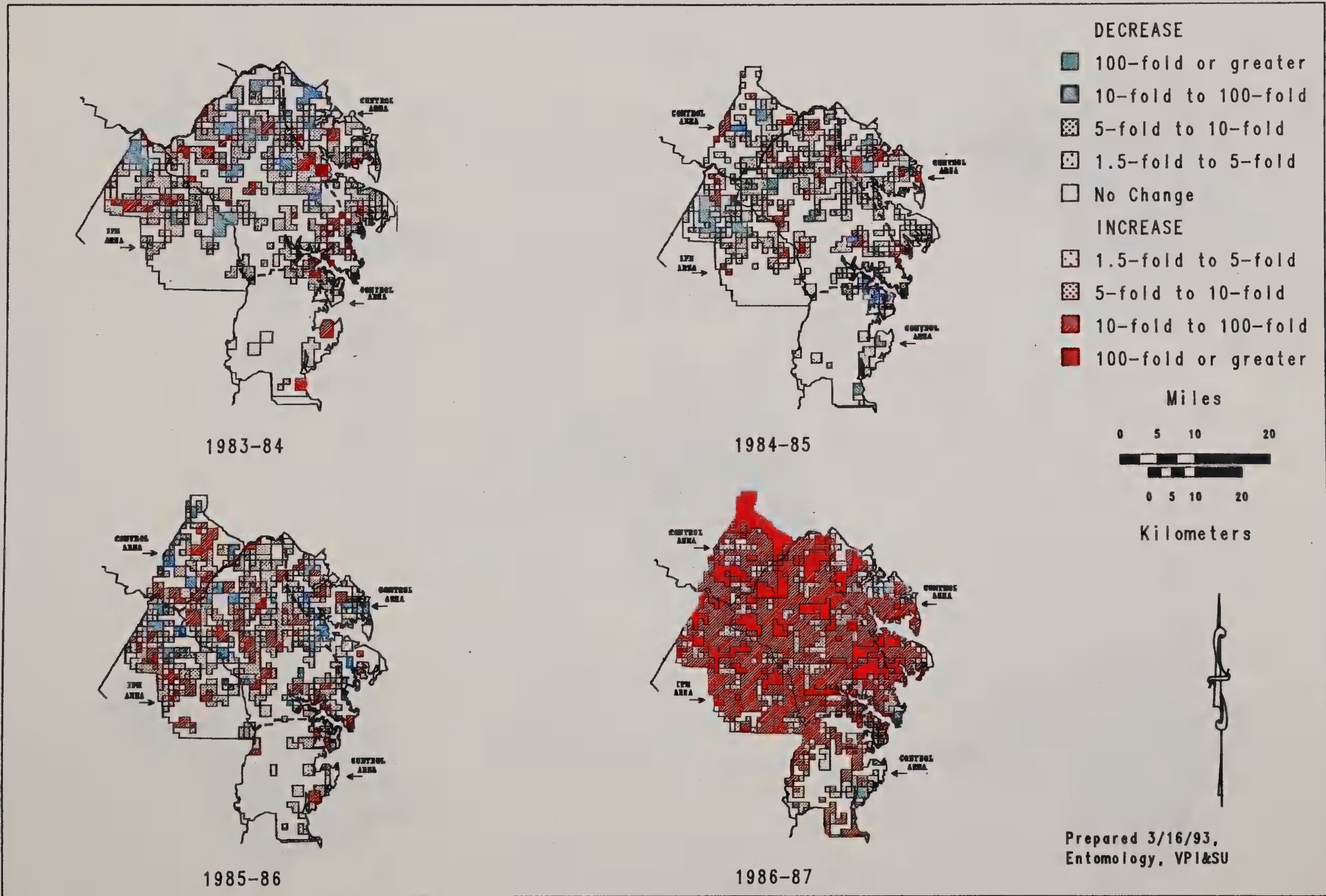


Figure 6: Change in egg mass density between years (1983-1987)

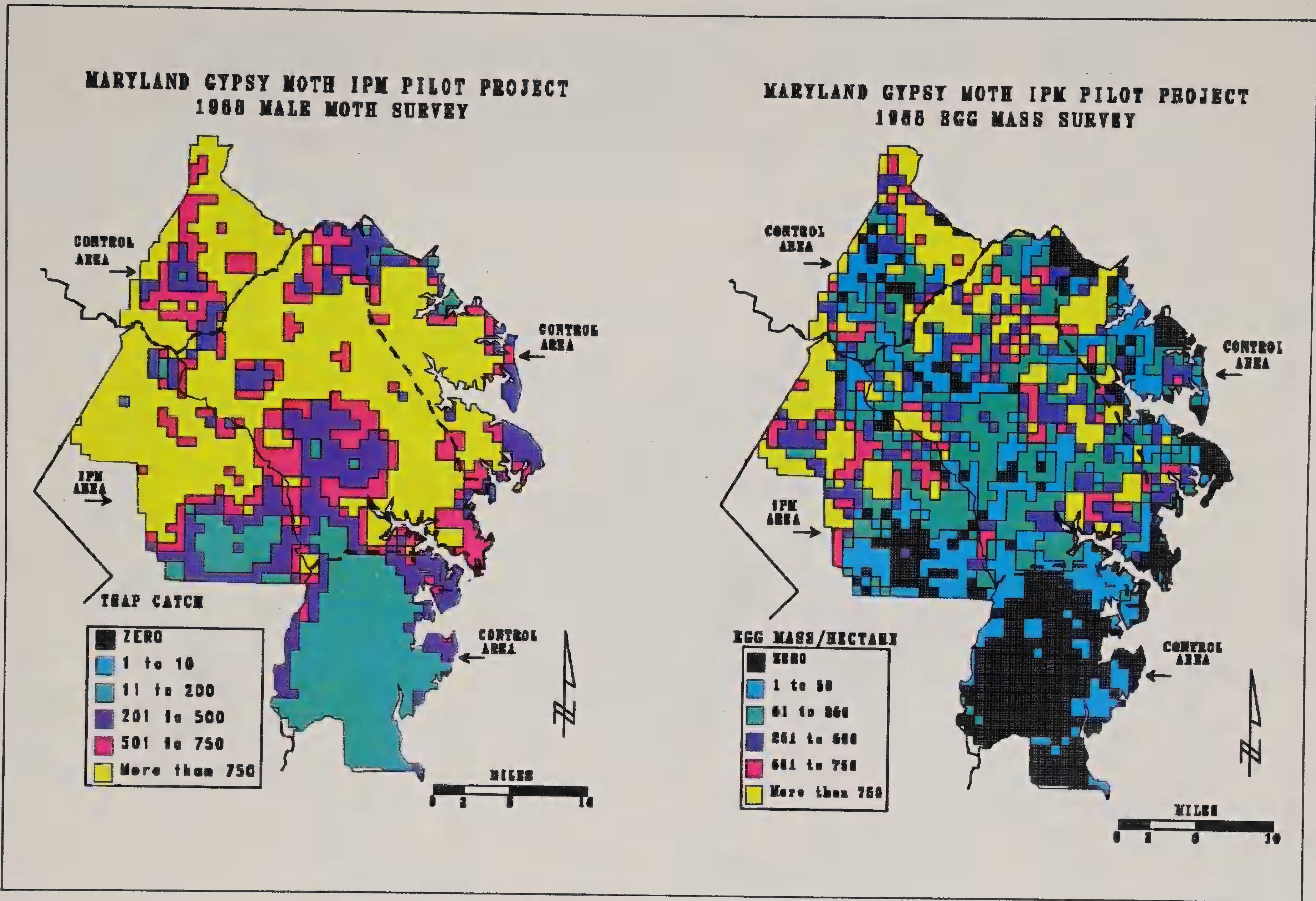


Figure 7: Male moth and egg mass survey data, 1988.

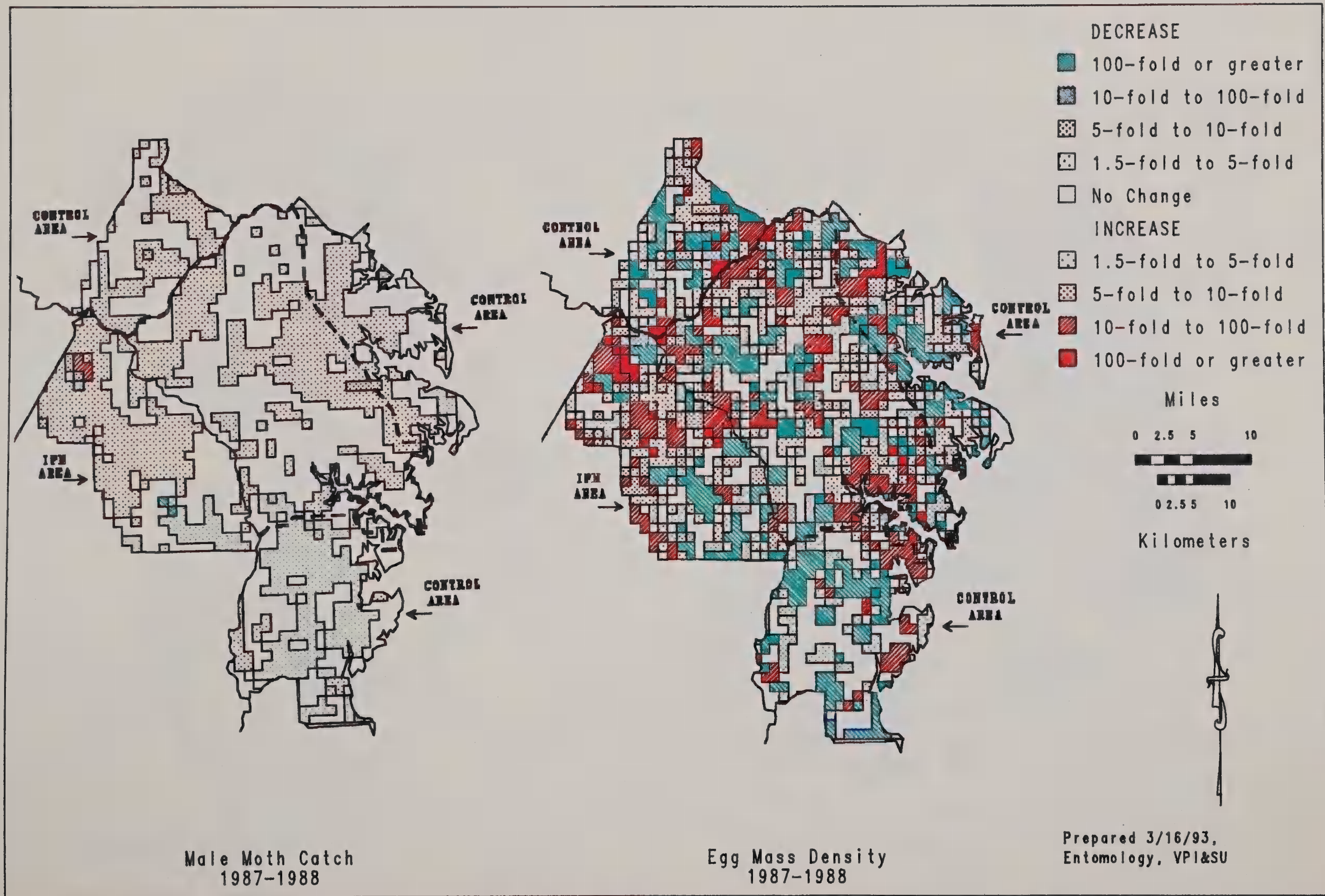
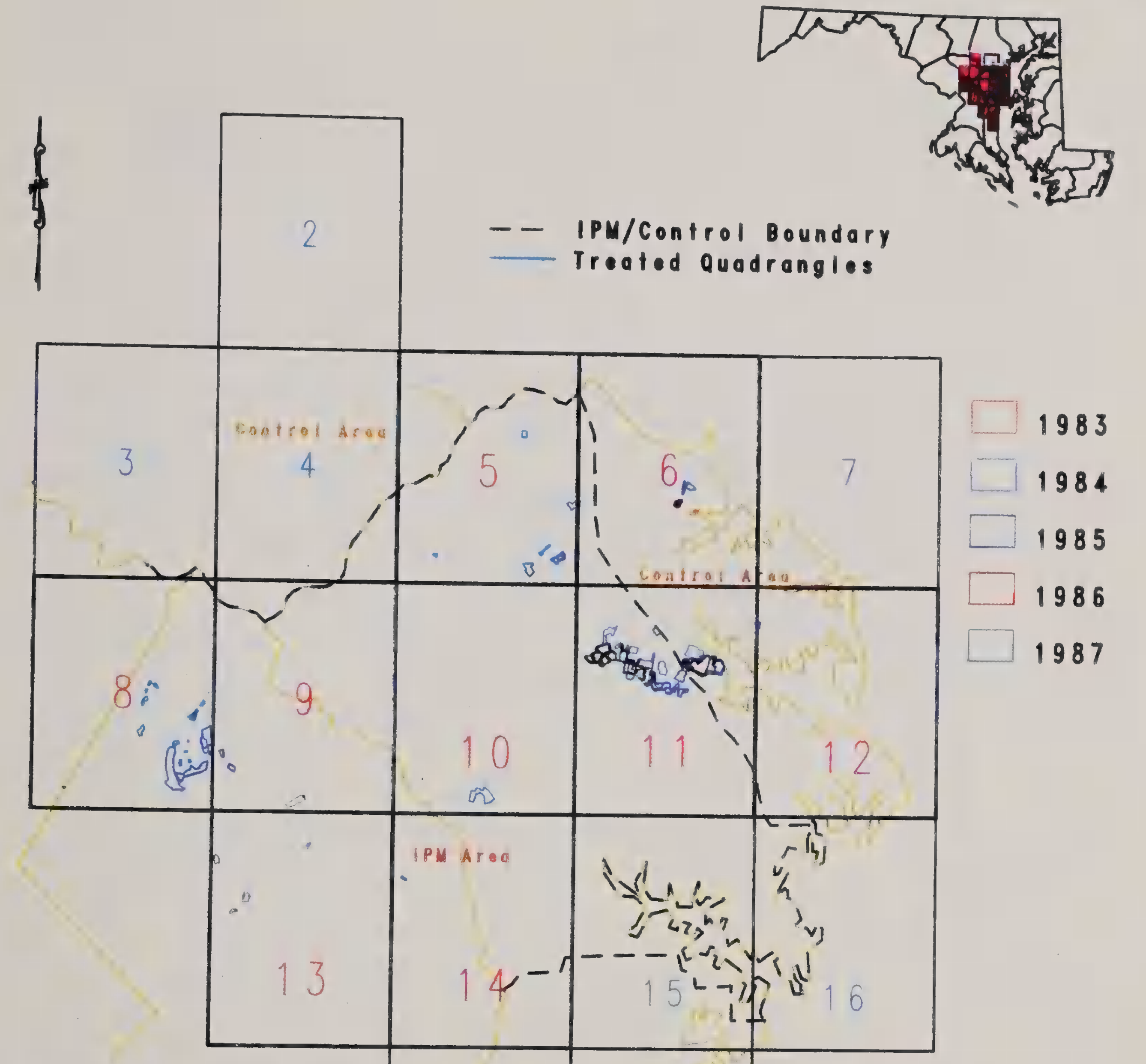


Figure 8: Change in male moth catch and egg mass density, 1987-1988.

Maryland Gypsy Moth Treatment Blocks 1983-1987



Hectares treated per year

year	area	type	hectares
1983	Control	Bt	103
1984	Control	Bt	155
1984	IPM	Bt	450
1984	IPM	Bt/Gf/Cm	534
1985	Control	Bt	135
1985	IPM	Bt	563
1985	IPM	Bt/Cm	234
1985	IPM	Dimilin	14
1985	IPM	Bt/L	74
1986	Control	Bt	102
1987	Control	Bt	244
1987	IPM	Bt	514

Bt=Bacillus thuringiensis
Gf=Glyptapanteles flavicoxis
Cm=Cotesia melanoscelus (Korean strain)
L=Luretape

Quadrangle Names (treated quads only)

5 Relay
6 Curtis Bay
8 Beltsville
9 Laurel
10 Odenton
11 Round Bay
12 Gibson Island
13 Lanham
14 Bowie

0 5
Miles

FIGURE 9: Maryland gypsy moth treatment blocks, 1983-1987.

Prepared by: Dept. of Entomology, VPI&SU

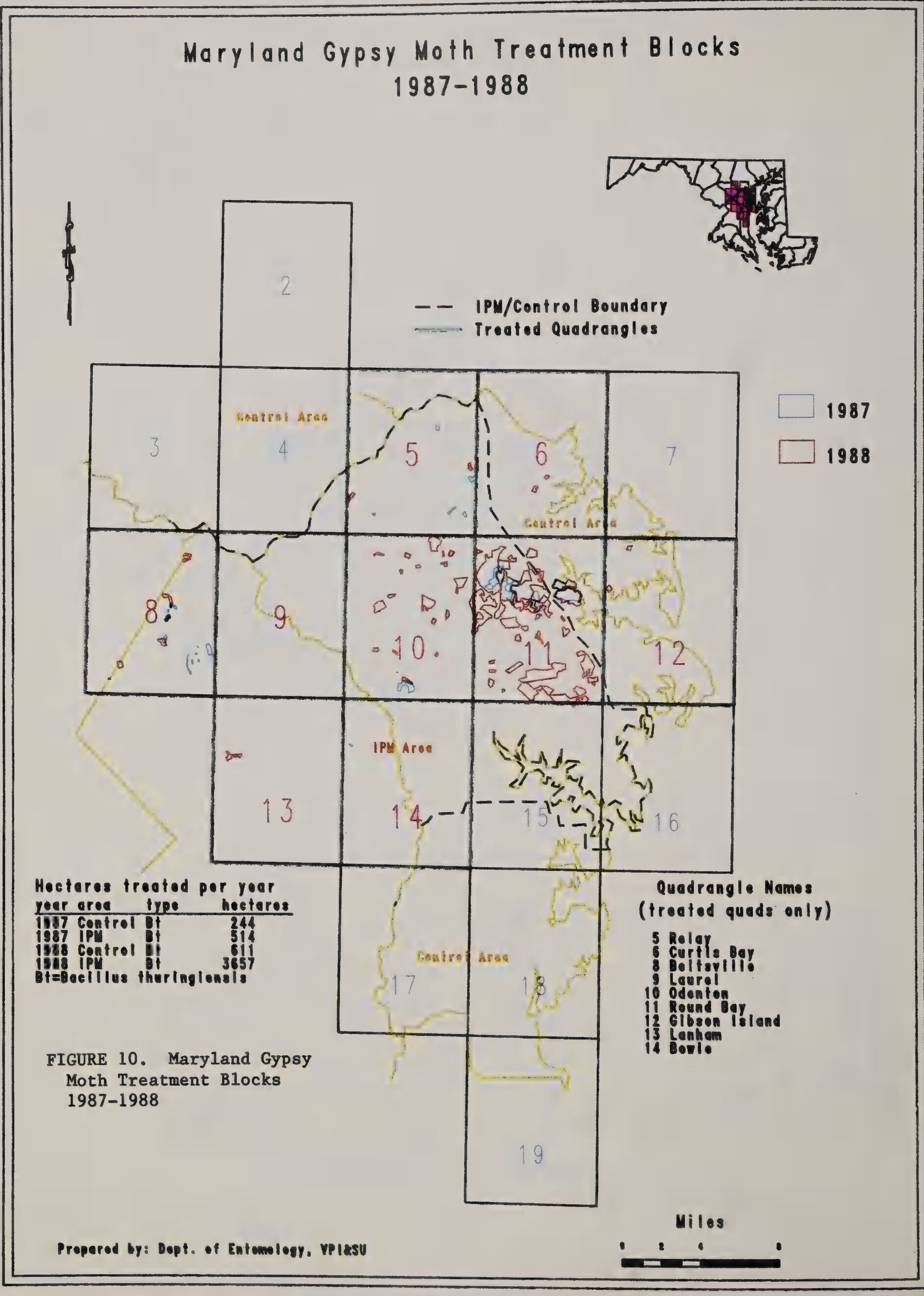


FIGURE 10. Maryland Gypsy Moth Treatment Blocks 1987-1988

Appendix III

MARYLAND GYPSY MOTH IPM PILOT PROJECT EGGMASS DATA FORM

RESIDENTIAL AND WOODLAND EGGMASS SURVEYS

SAMPLE 1 NO # EM	SAMPLE 2 NO # EM	SAMPLE 3 NO # EM	SAMPLE 4 NO # EM	SAMPLE 5 NO # EM	SAMPLE 6 NO # EM	SAMPLE 7 NO # EM	SAMPLE 8 NO # EM
ADDRESS	ADDRESS	ADDRESS	ADDRESS	ADDRESS	ADDRESS	ADDRESS	ADDRESS
1/10 ACRE	1/10 ACRE	1/10 ACRE	1/10 ACRE	1/10 ACRE	1/10 ACRE	1/10 ACRE	1/10 ACRE
1/40 ACRE	1/40 ACRE	1/40 ACRE	1/40 ACRE	1/40 ACRE	1/40 ACRE	1/40 ACRE	1/40 ACRE

Q.D. CODE	UTM COORDINATE

DATE		
MO	DAY	YR

COMMENT

TOPO ____________________

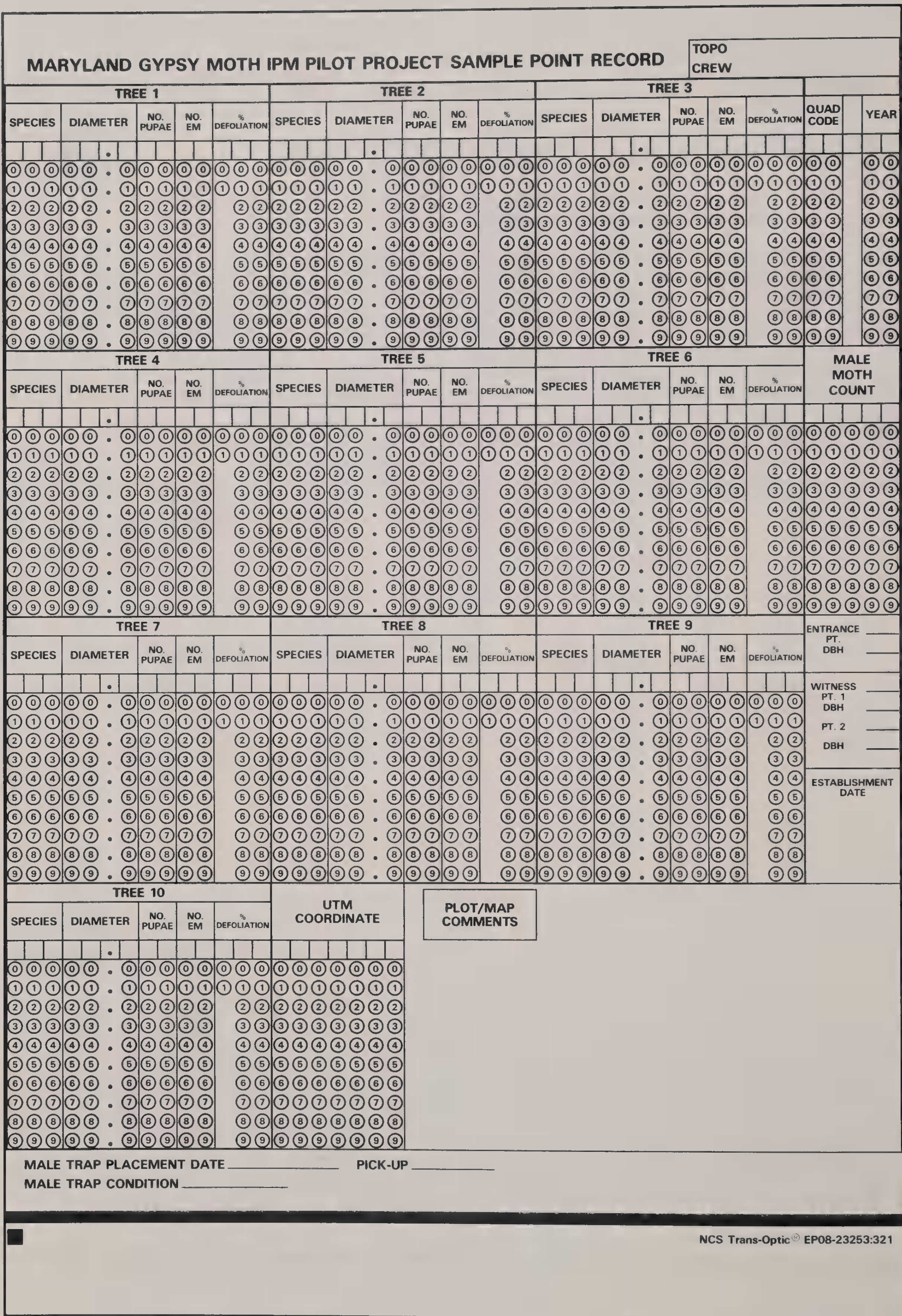
CREW ____________________

1/40 ACRE BARK FLAP SITE EGGMASS SURVEYS

SITE 1	NO # EM	SITE 2	NO # EM	SITE 3	NO # EM	SITE 4	NO # EM

NCS Trans-Optic® EP08-23254:321

Optical Scan Form. Maryland Gypsy Moth IPM Pilot Project Eggmass Data Form



MARYLAND GYPSY MOTH IPM PILOT PROJECT SAMPLE POINT RECORD

TOPO
CREW

TREE 1
SPECIES | DIAMETER | NO. PUPAE | NO. EM | % DEFOLIATION

TREE 2
SPECIES | DIAMETER | NO. PUPAE | NO. EM | % DEFOLIATION

TREE 3
SPECIES | DIAMETER | NO. PUPAE | NO. EM | % DEFOLIATION

QUAD CODE | YEAR

TREE 4
SPECIES | DIAMETER | NO. PUPAE | NO. EM | % DEFOLIATION

TREE 5
SPECIES | DIAMETER | NO. PUPAE | NO. EM | % DEFOLIATION

TREE 6
SPECIES | DIAMETER | NO. PUPAE | NO. EM | % DEFOLIATION

MALE MOTH COUNT

TREE 7
SPECIES | DIAMETER | NO. PUPAE | NO. EM | % DEFOLIATION

TREE 8
SPECIES | DIAMETER | NO. PUPAE | NO. EM | % DEFOLIATION

TREE 9
SPECIES | DIAMETER | NO. PUPAE | NO. EM | % DEFOLIATION

ENTRANCE PT. ____
DBH ____

WITNESS PT. 1 ____
DBH ____
PT. 2 ____
DBH ____

ESTABLISHMENT DATE

TREE 10
SPECIES | DIAMETER | NO. PUPAE | NO. EM | % DEFOLIATION

UTM COORDINATE

PLOT/MAP COMMENTS

MALE TRAP PLACEMENT DATE ____________ PICK-UP ________
MALE TRAP CONDITION ____________

NCS Trans-Optic® EP08-23253:321

Optical Scan Form. Maryland Gypsy Moth IPM Pilot Project Sample Point Record

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CAUTION:
PESTICIDES

Pesticide Precautionary Statement

This publication reports the aerial application of insecticides. It does not contain recommendations for insecticide use, nor does it imply that the uses discussed here have been registered. All uses of insecticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

Caution: Insecticides may be injurious to humans, domestic animals, desirable plants, and fish or other wildlife if they are not handled or applied properly. Use all insecticides selectively and carefully. Follow recommended practices for the disposal of surplus insecticides and insecticide containers.

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